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CREATING A BETTER WORLD

Questions, Actions and Expectations of International Students on Sustainable Development and Its Education

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ABSTRACT

Chemistry plays a key role in dealing with several of the big environmental problems of the future, but yet, chemistry education is often seen as irrelevant by students. Therefore, it is evident that ways to make chemistry education more relevant are called for. Educational experts have argued that sustainable development is a context that would bring relevance to science education, including chemistry education, as it bridges the gap between science and society. However, research on students' perspective on the relevance of sustainable development is scarce.

This thesis examines sustainable development and its education from the students' viewpoint. This is done by seeking to answer the research problem: **What do international students find relevant in sustainable development and its education?**

To answer this research problem, this thesis breaks down the problem into four research questions. The first research question examines what type of questions students ask about sustainable development, particularly in the area climate change. The second research question examines the kind of actions students take to make the world a better place. The third research question examines students' expectations when applying to a non-formal educational program focused on sustainable development. The last research question examines how these expectations were met through the non-formal educational program. To address the research problem, the thesis adopted a multi-method approach, consisting of descriptive research, case studies and elements of grounded theory. The data was collected before, during and after an international youth camp, the Millennium Youth Camp held in the summers of 2010-2014. The participants of the study were 16-19 -year old students from around the world who were interested in science.

The thesis consists of six interconnected studies. The first study examines the type of questions students ask about sustainable development and the second study examines the type of questions students ask about climate change, specifically. The data for these two studies were collected through an online survey from the students applying to the international youth camp. The data were analyzed using content analysis. The results indicate that students ask a variety of academic, societal and moral questions related to sustainable development. These questions cover many relevant aspects of sustainable development, and climate change specifically, and build a premise for student-centered education. In the third study, students attending the international youth camp were interviewed on the type of actions they take to make the world a better place. The data was analyzed though inductive and deductive content analysis and the results show that student actions can be categorized into three distinct groups, namely, personal responsible actions, participatory actions and future oriented actions.

The fourth study used quantitative methods to address what type of expectations students have in education for sustainable development. The data was collected from students applying to the non-formal education program. The results show that in addition to wanting more knowledge on specific scientific phenomena and the nature of science, students expect to learn about societal impacts of environmental issues and discuss related moral issues. Studies four, five and six examine how the aforementioned expectations of the students can be met through non-formal education. These studies examine what type of

structures and programs in the camp made the educational experience relevant for the students.

The thesis concludes by asserting that students' questions, actions and expectations can be used to make education for sustainable development more relevant in a number of ways. The thesis discusses the possibilities of (i) moving towards more student-centered learning, in which students' questions and actions are the foundation of education, (ii) increasing relevant social and societal discussion with peers and experts, and (iii) providing students with opportunities to work on projects that address student interest. The thesis takes examples from the non-formal educational program studied and discusses how these same methods could be implemented into other similar programs or formal education.

TIIVISTELMÄ

Kemian osaaminen on keskeistä kestävän kehityksen edistämiseksi ja globaalien ympäristöhaasteiden ratkaisemiseksi ja ennaltaehkäisemiseksi. Opiskelijat eivät kuitenkaan usein ymmärrä kemian merkityksellisyyttä kestävän kehityksen ja tulevaisuuden hyvinvoinnin kannalta. Kestävän kehityksen edistämiseksi tarvitaankin uusia oppilaslähtöisiä opetuksen lähestymistapoja, jossa aihetta tarkastellaan sen eri näkökulmista globaalisti. Toistaiseksi kestävän kehityksen opetusta opiskelijoiden näkökulmasta on kuitenkin tutkittu kemian kontekstissa vain vähän.

Tämä väitöskirjatutkimus tarkastelee kestävää kehitystä ja sen opetusta kansainvälisten opiskelijoiden näkökulmasta. Tarkastelun tavoitteena on vastata päätutkimusongelmaan: **Mitä 16–19 -vuotiaat opiskelijat pitävät merkityksellisenä kestävässä kehityksessä ja sen opetuksessa?** Ongelma on jaoteltu neljään tutkimuskysymykseen. Ensimmäinen tutkimuskysymys tarkastelee, minkälaisia kysymyksiä nuoret opiskelijat kysyvät kestävästä kehityksestä ja erityisesti ilmastonmuutoksesta. Toinen tutkimuskysymys tarkastelee, minkälaisia tekoja opiskelijat tekevät parantaakseen maailmaa. Kolmas tutkimuskysymys tarkastelee opiskelijoiden ennakko-odotuksia heidän hakiessa kansainväliselle Millennium Youth Camp tiedeleirille, jossa pääteemana on kestävä kehitys. Neljäs tutkimuskysymys tarkastelee, miten leiri vastasi nuorten ennakko-odotuksiin leiristä ja sen sisällöstä. Tutkimuksessa käytettiin seuraavia menetelmiä: kuvaileva tutkimus (engl. descriptive research), tapaustutkimus ja grounded theory. Aineistoa kerättiin ennen kansainvälistä tiedeleiriä, leirin aikana sekä leirin jälkeen vuosina 2010–2013.

Tämä väitöskirja koostuu kuudesta, toisiinsa liittyvästä tutkimuksesta. Ensimmäinen tutkimus tarkastelee, minkälaisia kysymyksiä nuoret kysyvät kestävästä kehityksestä ja toinen tutkimus, minkälaisia kysymyksiä nuoret kysyvät ilmastonmuutoksesta. Näiden kahden tutkimuksen aineisto kerättiin nettikyselyllä niiltä nuorilta, jotka hakivat leirille. Aineisto analysoitiin sisältöanalyysin menetelmin. Tulokset osoittavat, että nuorten kysymykset liittyvät kestävän kehityksen tieteellisiin, yhteiskunnallisiin ja moraalisiin ulottuvuuksiin. Nämä kysymykset kattavat kestävän kehityksen ja ilmastonmuutoksen osa-alueita hyvin laajalti ja luovat perustaa sille, miten opetuksessa voitaisiin siirtyä oppilaskeskeisempään lähestymistapaan. Kolmannessa tutkimuksessa selvitettiin haastatteluja käyttäen, minkälaisia tekoja leirille tulleet nuoret tekevät ympäristön ja maailman hyväksi. Aineisto analysoitiin käyttäen induktiivista ja deduktiivista sisältöanalyysiä. Tutkimuksen tulokset osoittavat, että nuorten teot voidaan jakaa kolmeen ryhmään: henkilökohtaiset vastuulliset teot, yhteisölliset teot ja tulevaisuuteen tähtäävät teot.

Neljäs tutkimus käytti kvantitatiivisia menetelmiä, selvittääkseen minkälaisia odotuksia nuorilla on kestävän kehityksen opetuksesta. Aineosto kerättiin nuorilta, jotka olivat hakemassa kansainväliselle tiedeleirille. Tulokset osoittivat, että sen lisäksi että nuoret haluavat lisää tietoa luonnontieteistä ja luonnontieteen luonteesta, he myös haluavat oppia yhteiskunnallisista ulottuvuuksista ja ympäristön ongelmista. Myös näihin liittyvät moraaliset keskustelut ovat heille tärkeitä. Tutkimukset neljä, viisi ja kuusi tutkivat, miten näihin nuorten odotuksiin voidaan vastata selvittämällä, minkälaiset rakenteet ja ohjelmat tekivät leireistä merkityksellisiä oppimisympäristöjä opiskelijoille.

Tutkimus tuo lisätietoa oppilaslähtöisen kestävän kehityksen opetuksen suunnittelun ja toteutuksen tueksi. Esimerkiksi nuorten kysymykset, teot ja odotukset ilmastonmuutokseen liittyen on tärkeä huomioida kemian opetuksessa. Kestävän kehityksen merkityksellisessä opetuksessa olisi hyvä huomioida seuraavat tavat: (i) siirtyä oppilaskeskeisempään opiskeluun, jossa opiskelijoiden kysymykset ja teot muodostavat opetuksen lähtökohdan, (ii) lisätä merkityksellistä yhteiskunnallista keskustelua opiskelijoiden kesken ja asiantuntijoiden kanssa ja (iii) antaa opiskelijoille mahdollisuus työskennellä projekteissa, jotka vastaavat heidän omia kestävään kehitykseen liittyviä mielenkiinnon kohteita. Väitöskirjassa esitetään myös, miten näitä leirillä tutkittuja lähestymistapoja voitaisiin siirtää kouluopetukseen.

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LIST OF ORIGINAL PUBLICATIONS

This thesis is based on the following publications:

I Tirri, **Tolppanen**, Aksela & Kuusisto (2012). A Cross-Cultural Study of Gifted Students' Scientific, Societal and Moral Questions Concerning Science. *Education Research International*. 2012, 1-7.

II **Tolppanen** & Aksela (submitted). Towards a More Holistic Climate Change Education – Students' Perspective.

III Vesterinen, **Tolppanen** & Aksela (in press). Towards Citizenship Science Education: What Students do to make the World a Better Place? *International Journal of Science Education*.

IV **Tolppanen**, Vartiainen, Ikävalko & Aksela (2015). Relevance of non-formal Education in Science Education. In I. Eilks (Ed.), *Relevant Chemistry Education - From Theory to Practice*. pp 325-344. Sense Publishing.

V **Tolppanen** & Tirri (2014). How an Enrichment Summer Program Is Meeting the Expectations of Gifted Science Students: A Case Study from Finland. *International Journal of Talent Development and Creativity*, 2(1), 103-115.

VI **Tolppanen** & Aksela (2013). Important Social and Academic Interactions in Supporting Gifted Youth in Non-Formal Education. *LUMAT*. 1(3), 279-298.

The publications are referred to in the text by their roman numerals.

Author's contributions to the publications:

I: The author was co-responsible for planning the research and collecting and analyzing the data. The author was involved in the writing of all parts of the article.

II, V, VI: The author was responsible for planning the research and collecting and analyzing the data. The author was involved in the writing of all parts of the article.

III: The author was co-responsbile for planning and setting up the research. The author participated in analyzing the data and writing the article.

IV: The author was responsible for planning and organizing the study, writing the theoretical framework, the section on *Non-formal education for gifted 16–19 year old students* and the conclusions.

ABBREVIATIONS

etc.	et cetera
e.g.	exempli gratia
ESD	Education for Sustainable Development
NOS	Nature of Science
SSI	Socio-Scientific Issues

CONTENTS

1. INTRODUCTION

Chemistry plays a key role in solving many of the environmental challenges of today and tomorrow. For instance, chemistry is important in finding ways to preserve and replace our diminishing resources (such as oil, minerals and clean water), as well as finding solutions to eutrophication, climate change and erosion of farmlands. However, research conducted around the world shows that students tend to see science education, including chemistry education, as irrelevant (Hofstein, Eilks, & Bybee, 2011; Osborne & Dillon, 2008). Therefore, it is apparent that the goals and content of the chemistry curriculum do not meet the needs and expectations of students (see Hofstein et al., 2011). Researchers have suggested that this is because the chemistry curriculum is often decontextualized from the students' everyday lives (Aksela & Karjalainen, 2008; Hofstein et al., 2011). Recent research has also shown that especially societal relevance is lacking in chemistry education (Hofstein et al., 2011; Stuckey, Hofstein, Mamlok-Naaman, & Eilks, 2013). Therefore, this thesis aims to find out how education could be made more relevant, namely through sustainable development and non-formal education. Although examining how to make education more relevant is by no means a new endeavor, this thesis brings a new perspective to the discussion by focusing on the students' perspective. This is done by examining the following research problem:

What do international youth find relevant in sustainable development and its education?

As this research problem is broad and complex, answering it as such is challenging. For this reason, this thesis focuses on four research questions that add to the discussion of the main research problem. These research questions are:

> **RQ1**: What type of questions do students ask about sustainable development?
> **RQ2**: What type of actions do students take to make the world a better place?
> **RQ3**: What type of expectations do students have for non-formal education with a context of sustainable development?
> **RQ4**: How can students' needs and expectations be met through non-formal education?

The relationship between the research problem, the research questions and the six studies presented in this thesis are presented in Gigure 1. However, it is important to note that the figure is a simplification of the relationships between the research questions and the studies. For instance, students' questions (RQ1) give indication of the students' educational expectations (RQ3), though a link between the two is not drawn in the figure. Furthermore, the findings of students' questions (RQ1) and actions (RQ2) contribute to the discussion on how students' expectations can be met (RQ4). In sum, all of the studies

and research questions interlink with each other. However, drawing all of these connections into the figure would only make it hard to read.

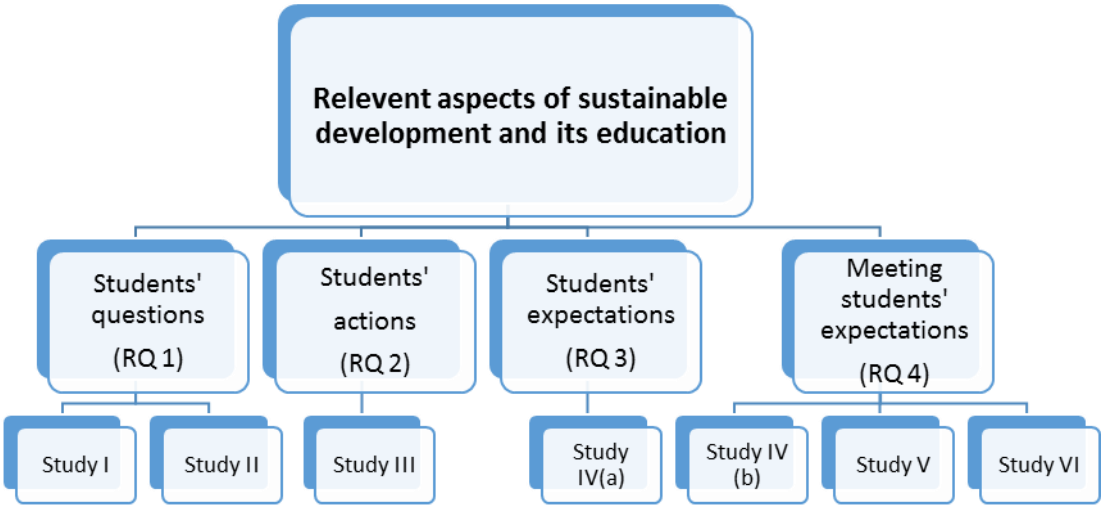

Figure 1. *A simplified structure on how the research problem, research questions and the studies are connected.*

To answer the first research question, this thesis includes two studies on the topic. **Study I** gives a broad outline on what kind of questions students ask about sustainable development in a science context. **Study II** then goes deeper into this topic by analyzing what type of questions students ask about climate change in specific. The significance of these two studies in relation to student-centered education (e.g. Jonassen, 2000) will be discussed. The second research question is answered through **Study III**, in which students are interviewed on the kind of actions they take in order to make the world a better place. The results of this study add to the discussion of action competence (see Hofstein et al., 2011), an important aspect of relevant Education for Sustainable Development (ESD). **Study IV (a)** aims to answer the third research question by studying what type of expectations students have before attending a non-formal educational program. Students' expectations go beyond academic expectations, and therefore, in order to provide relevant education for the students, non-academic aspects should be acknowledged in education, as will be discussed further in this thesis. The final research question is answered with the help of three studies presented in this thesis. **Study V** discusses the relevance and non-formal education in general. **Study IV (b)** and **Study VI** then discuss how students' expectations can be met through relevant non-formal science education. In the general conclusions, the findings of the six studies are linked to the main research problem on what international youth find relevant in education for sustainable development.

Before presenting the actual studies, this thesis will present a theoretical framework that is needed to understand the studies, and the discussion to follow. This framework is presented in Chapters two and three, discussing sustainable development and relevant

education, respectively. The theoretical framework will help the reader understand the importance of this thesis, as well as why a students' perspective was chosen.

The fourth Chapter presents the methodological framework for the study, presenting how descriptive research, cases studies and elements of grounded theory were used in this thesis. The reason for selecting these particular methodologies is also justified. Chapter five summarizes the six studies presented in this thesis and is divided into four sections, based on the research questions. The methods used for data collection and the main results of each study are presented in this chapter. The sixth Chapter examines the validity and reliability of the thesis. The seventh and final Chapter of this thesis brings the six studies together by discussing the implications of the findings and the thesis as a whole. The Chapter also suggests areas in which further research should be conducted.

2. SUSTAINABLE DEVELOPMENT AND ITS EDUCATION

In order to create a better world, society must learn to take the limits of the environment into consideration (see e.g. Meadows, Meadows, Randers, & Behrens, 1972). However, overconsumption of resources is currently the norm, causing many environmental challenges, such as climate change, eutrophication and erosion of farmlands. In order to prevent these challenges from escalating, education on how to reach a sustainable level of consumption is needed.

This chapter first discusses what sustainable development means and why achieving sustainable development is important. It then outlines the history and the current discussion on education for sustainable development. Finally, this chapter presents a specific case related to education for sustainable development, namely climate change education.

2.1. Sustainable Development

Sustainable development has numerous definitions (Johnston, Everard, Santillo, & Robert, 2007), though the most common and well known one is the definition from the Brundlands' report (World Commission on Environment and Development (WCED), 1987). In the report, sustainable development was defined as *development that meets the needs of the present without compromising the ability of future generations to meet their own needs* (WCED, 1987).

Typically sustainable development is thought to consist of three pillars, namely, the environment, the society and the economy. Other pillars, such as culture, are also commonly presented (Jon Hawkes, 2001), though not accepted as widely as the prior three. As sustainable development attempts to combine environmental concerns with socio-economic issues (Hopwood, Mellor, & O'Brien, 2005), sometimes contradicting interests are at play (see e.g Ehrlich & Holdren, 1971; Robinson, 2004). On the one hand, overconsumption of natural resources is causing society to be more concerned for the wellbeing of the environment and future generations. But on the other hand, psychology has shown that humans are loss adverse (Kahneman & Tversky, 1979) and often chose immediate gratification over delayed gratification (Mischel, 1973). In the context of sustainable development, this means that individuals value the already achieved high living standard so much that taking environmental actions – with a decrease in living standards – is not compelling.

Furthermore, it is not uncommon for people to believe that the development of science and technology will solve the environmental problems society is facing. However, as has been pointed out by Ehrlich and Holdren, (1971) there are a number of factors that are causing an environmental impact. At least three factors affect the impact (I) on the environment, namely population (P), affluence (or goods consumed per capita) (A) and technology (T). The role of these three was debated already in the 70's (Commoner, 1972; Ehrlich & Holdren, 1971) resulting in the formulation of the following equation:

(1) $I = P \times A \times T$

Since the creation of the model, other, more complex, models have also emerged (see e.g. Hynes, 1993). However, the bottom line in the different models is that science and technology on their own do not seem to be sufficient to decrease environmental impact. For instance, the technology currently available can help decrease environmental impact, but it is not enough to diminish the negative impact caused by an increasing population and affluence (York, Rosa, & Dietz, 2002).

Currently, at least in the western world, our culture is driven by affluence. As affluence is strongly linked with economics, it can cause an imbalance in the three pillars of sustainable development. Some feel that this imbalance is causing harm to society, as is depicted in Figure 2.

Figure 2. *The imbalance of the three pillars of sustainable development* (A31, 2006)

Therefore, for people to understand the role of science and technology in solving environmental problems, education for sustainable development (ESD) is needed. For such education to be useful, it should take into consideration all three pillars of sustainable development, meaning that it cannot be subject specific. Education needs to be multidisciplinary, as will be highlighted in the following sections.

2.2. Education for Sustainable Development

For the past few decades, sustainable development has been seen as an important part of education. The UN especially has been strongly pressing the agenda for ESD from as

early as 1992 (see United Nations Conference on Environment and Development, 1992), when the importance of ESD was highlighted in Agenda 21. The UN also declared 2005-2014 the decade of education for sustainable development (UNESCO, 2015) and is continuing to pursue ESD through the Global Action Project (GAP) (UNESCO, 2014), which, more or less, continues from where the decade of education for sustainable development left off.

Partially due to the heavy actions by the UN, the importance of ESD has been noted widely, resulting in the creation of a number of models on how to incorporate ESD (e.g. de Haan, 2006; McKeown, Hopkins, Rizi, & Chrystalbridge, 2002; Paden, 2000) Many of these models have some traits in common. The most essential elements were summarized by Eilks & Hofstein (2014) as follows:

- *Learning about natural and man-made environments using an integrated view of their social, political, ecological and economic (and possibly cultural) dimensions, including involvement at the local and global levels*
- *Focusing on participatory learning while aiming to promote citizenship skills through an ethics- and values-driven approach*
- *Orienting learning on system-based thinking, including the use of interdisciplinary, learner-centered, experiential and inquiry-based methods*
- *Focusing on life-long learning as a perspective which integrates formal and informal education*

In sum, the list suggests that societal issues need to be implemented thoroughly, interdisciplinary approaches need to be adopted and pedagogical methods need to be changed (Eilks & Hofstein, 2014). Needless to say, implementing these aspects into science education brings about some challenges.

One of the greatest challenges may be to incorporate societal issues into science education. Educational researchers have already argued for such an approach for decades (e.g. Bybee, 1987; Hurd, 1970). Yet, even today, science education is sometimes largely disattached from its societal context (Gilbert, 2006). Of course, there is hope that the realization of the importance of sustainable development may change this, but if history is any indication, it will take time.

On a larger scale, moving towards interdisciplinary education would require a paradigm shift from a traditional, subject specific approach, towards a citizenship education approach. This change has already started to take place, since during the past few decades there has been ongoing discussion on incorporating education in science, technology, society and environment (STS and STSE) (e.g.Bybee, 1987; Pedretti & Nazir, 2011). Furthermore, bringing socio-scientific issues (SSI) into science education have been highly encouraged (e.g. Ratcliffe & Grace, 2003). These would not only help students understand the relationship between science and society, but also bring to discussion many moral issues crucial for citizenship education. In essence, the paradigm shift should include aspects of economics, social sciences and the humanities into science education (see Eilks & Hofstein, 2014)

Someone may wonder why all of these fields should be brought under one roof rather than teach them as separate subjects, as has been done previously. The main reason for this is that students often have difficulties transferring knowledge to new situations (e.g. Gilbert, Bulte, & Pilot, 2011). Therefore, if the multidisciplinary dimensions of sustainable development are taught in different classes without teachers helping students make the links between the subjects, the links may not be made at all.

The ESD models also call for new pedagogical approaches, such as student-centered education and inquiry-based learning. A more extensive summary of the different educational approaches was presented by Juntunen and Aksela (2014) in the following figure:

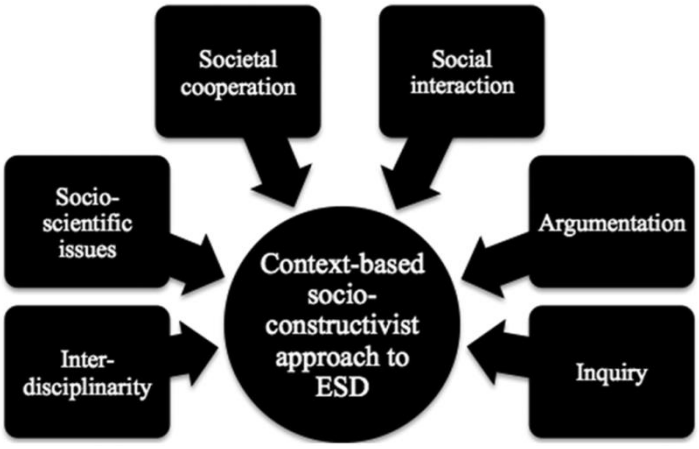

Figure 3. *Methods to approach ESD education* (Juntunen & Aksela, 2014).

As shown in Figure 3, using multiple pedagogical approaches in ESD is needed. This shift from traditional pedagogical methods will require effort from teachers. However, moving towards such new methods is reasonable, as the aim of ESD is not only for students to gain knowledge, but also to learn to make decisions and to take action (e.g. Jensen & Schnack, 1997). Furthermore, students should learn to be responsible, not only for themselves, but for future generation as well (de Haan, 2006).

2.2.1 Climate change education

Currently, one of the major environmental threats hindering sustainable development is climate change (Rockström et al., 2009). Although climate change is a natural phenomenon, in the past two centuries it has been enhanced by human behavior (IPCC, 2014). This has not only caused faster than usual changes in the environment, but has also raised societal questions on the sustainability of human consumption, and on how society is prepared for the possible consequences of climate change (see Meadows et al., 1972).

Because of the large amount of environmental and societal issues involved in climate change, it is relevant for future citizens to understand the topic. Education on climate change has already been implemented into many national curricula (Schreiner, Henriksen,

Kirkeby, & Pål, 2005), but in many cases the focus is on the scientific aspects, the societal aspects getting little or no consideration (e.g. Gayford, 2002; Schreiner et al., 2005). However, educational experts have argued that for students to become scientifically literate, students should understand the link between societal and scientific issues (e.g. Zeidler & Keefer, 2003).

Climate change education needs to include scientific facts on how the climate works as a system. Researchers (Shepardson, Niyogi, Roychoudhury, & Hirsch, 2012) have suggested that a system analysis of climate change should include at least the following six dimensions:

1. Natural causes and changes to the climate system
2. Atmosphere and pollution
3. Snow and ice levels
4. Oceans (levels, temperature and life)
5. Land and vegetation
6. Human impact

(See Shepardson et al., 2012 for more details)

These dimensions are important in understanding climate change as a system, but as is discussed further in **Study II**, they don't encompass societal and moral discourse extensively. In order for students to understand the other dimensions of climate change, some researchers (see e.g. Moser & Dilling, 2004; Schreiner et al., 2005) have argued that climate change education should include political, economic, ethical and psychological aspects in addition to the scientific ones. However, as the array of aspects that should be taught is wide, teachers may be incompetent to teach climate change (e.g. Ocal, Kisoglu, Alas, & Gurbuz, 2011; Papadimitriou, 2004) and would rather maintain the integrity of their subject, rather than teach on multidisciplinary aspects (Gayford, 2002). Furthermore, as climate change involves many moral questions, the teachers' own emotions can affect their teaching (Lombardi & Sinatra, 2013). One way to overcome these challenges is to move more towards student-centered education and non-formal education, as they provide the opportunity to diverge from the traditional way of teaching, where the teacher needs to be the "all knowing expert".

3. RELEVANT EDUCATION

The primary goal of education, whether it is regarding green chemistry, sustainable development or climate change, is for it to be relevant. Unfortunately, learners find science education 'irrelevant' for themselves as well as for society (Dillon, 2009; Gilbert, 2006). This has contributed to science education being unpopular among students (e.g. Osborne, Simon, & Collins, 2003). Moving towards more relevant science education is clearly needed, but the challenge is that there has been ambiguity on what is meant by relevant education (see Stuckey et al. 2013 for more details) and to whom it should be relevant.

This chapter first presents a way to define relevant education and then discusses some pedagogical methods that can be used to achieve relevant education.

3.1. Defining Relevant Education

In the late 50s and early 60s, science education was primarily used as a tool to recruit future scientists, medical doctors and engineers (DeBoer, 2000). This continues to be so in many western countries (Osborne & Dillon, 2008). Such an approach makes science education only relevant for those students who want to pursue a science career, and therefore, was strongly criticized in the late 60s and 70s (see e.g. Osborne et al., 2003). As a result, education reforms were made with the aim that students would be "scientifically literate", or that science education would be "science for all" (Dillon, 2009). The goal was to enforce social and personal goals for science education. However, it was not until the 80s that societal issues started to play a larger role in science education (Yager & Hofstein, 1986), and not until the 90s that socio-scientific issues were starting to be used as the basis to teach current and future implications of science and technology to society (Marks & Eilks, 2009). However, during the past few decades education has become more relevant for students. Even today the science contexts taught are sometimes largely detached from their societal, ecological and economic contexts (Gilbert, 2006).

In order to address this problem, Stuckey et al. (2013) have suggested that in order for education to be relevant, it needs to be relevant to the individual, to society and to the future vocation of the student. In their work, they define individual relevance as something that meets the direct needs of the students by providing them with skills and knowledge to understand the world around them, pass school exams and feed their curiosity. Societal relevance is defined as giving students the tools to become active members of society, and putting their education into a context that helps them better understand the world around them. Vocational relevance refers to giving students the skills and knowledge they need to find work, and become useful members of the workforce. Each of these three dimensions has a present and future dimension, as well as an intrinsic and extrinsic dimension (See Stuckey et al. 2013 for more details). In order to make education relevant for the learner, all of these dimensions of relevance should be addressed. However, the societal dimension is often neglected in science education (Hofstein et al., 2011).

In order to address all three domains of relevance in an integrated way, Eilks and Hofstein (2014) see that the best approach is to build the science curricula around controversial issues where science and society interact, also known as socio-scientific issues (see e.g. Sadler, 2011). One approach in dealing with such socio-scientific issues is to use sustainable development as a context, as it interlinks scientific and societal aspects, connecting them to the environment and to economics.

In order to attain relevant education, a variety of approaches should be used. The next sections will present student-centered education, education for action competence, non-formal education and education for the gifted, as examples.

3.2. Student-Centered Education

The aim of student-centered education is to provide a learning environment in which the students take an active role in their learning (Hannafin, 1992) by deciding all or some of the learning goals, resources and activities used (Jonassen, 2000). Such learning can be supported by interactive activities that meet the students' unique learning interests and style (Hannafin & Land, 1997). However, in order to be successful, student-centered learning must have an interesting problem or question to tackle, so that the students stay motivated (Pedersen & Liu, 2003). Also, the teacher needs to be able to acknowledge and enforce students' interests, talents, learning styles and different stages of development (Pedersen & Liu, 2003; Teaching Excellence in Adult Literacy (TEAL), 2011).

Though student-centered education seems to improve at least students' critical thinking skills, creativity, motivation and student satisfaction (Cornelius-White, 2007), it has not been strongly implemented in schools (Estes, 2004). The reasons for this may lie in curriculum restrictions as well as the reluctance of teachers to change their teaching habits (Richardson, 1998).

However, student-centered learning has great potential in overcoming some of the educational challenges that hinder moving towards ESD and relevant education. For one, a student-centered approach allows personalized learning, making it possible to emphasize the three dimensions of relevance in different ways to different students. Furthermore, it can compensate for a teacher's lack of competence in a multidisciplinary field, such as climate change. In fact, researchers have argued that teachers' lack of competence is the main reasons why student-centered education is important (Pekel & Özay, 2005). In addition, as student-centered learning encourages setting personalized learning goals, it can help students become life-long learners.

In this thesis, **Study I** and **II** examine the type of questions students ask about ESD and discuss how students' questions could be used to move further towards a student-centered learning approach.

3.1.1 Action competence

In the context of environmental education and sustainable development, one of the primary goals for student-centered education is that students learn to take action on environmental concerns (see Jensen & Schnack, 1997). In the ESD model presented in section 2.1, such an ability is encompassed in the idea of teaching students to become active citizens, but it is also commonly referred to as action competence (e.g. Jensen & Schnack, 1997).

Jensen and Schnack (1997) define action competence as the ability and the will to take action on certain issues. They make a clear distinction that action competence is not merely behavioral change, but rather, they imply that it is an attitudinal change, resulting from understanding why actions are needed. They also make a distinction between action competence and activity. They argue that educators may, at times, try to move away from the academic approach of environmental education by introducing activities, such as visiting an "untouched" forest, or doing hands-on experiments on the chemical, physical and biological properties of the water in a nearby pond. However, as such, these activities do not increase a student's willingness to take action, and therefore, do not meet the criteria for action competence.

Providing science education with the aim of increasing students' action competence would require the incorporation of student-centered education and a multidisciplinary approach. However, a shift towards such education would not only be significant for the environment, but could help students notice the individual and societal relevance of science.

Though action competence (Jensen & Schnack, 1997) and active citizenship (Eilks & Hofstein, 2014) are seen as crucial parts of ESD, studies on students' action competence or their perspective on active citizenship are scarce. In this thesis, **Study III** examines the kinds of actions that students take as active citizens. The thesis will also discuss how knowledge on these actions could be used to make science education more relevant.

3.3. Non-Formal Education

Since the 1960's there has been an increasing amount of discussion on the need for out-of-school education (Belle, 1982). Originally, out-of-school education was aimed for those who did not have the opportunity to attend formal education, but today it is used to respond to a large array of new and different demands of education, such as educating particular groups of students (e.g. scientifically gifted) in a specific field (e.g. sustainable development) (Finland's Science Education Centre, 2012).

Out-of-school education, such as camps and fieldtrips (Eshach, 2007), are commonly referred to as non-formal education, as it takes place in less formal settings than formal education. However, non-formal education also has other distinctions from formal education. The most easily notable difference is that non-formal education is usually voluntary for the students, learning is not evaluated, and learning is not restricted to national guidelines, such as a curriculum (Eshach, 2007). This freedom gives non-formal

education the possibility of dealing with issues either more specifically, or more holistically, depending on what the educators want. It also gives the freedom to deal with relevant, cutting-edge topics that are not yet present in national curricula.

Non-formal education has many benefits, such as giving students the possibility to learn more about the issues in which they are interested. Furthermore, non-formal education has been shown to positively affect the attitudes and motivation of students. For instance, Pedretti (2002) has stated that science fieldtrips and trips to science centers can increase students' interest and sense of wonder towards science. This then increases their motivation, enthusiasm and eagerness to learn (Pedretti, 2002). What is also significant is that these attitudes can persist over time (Rennie, 1994; Rhodes, 2013) and can result in further engagement in the topic (Germann, 1988). In addition, the social interactions in non-formal education can be significant, as students can reflect what they have learned with teachers and like-minded students (Rahm, 2004).

In the summary of ESD models (see section 2.1) it was stated that lifelong learning should be supported by the integration of informal and formal education. However, non-formal education should also be added to the list, as it has much potential, as will be seen in the results from **studies IV, V** and **VI**.

3.4. Gifted Education

The studies in this thesis occasionally refer to *gifted education*, or *education for the gifted*.

Defining gifted education is relatively easy as, in essence, it refers to educating a specific group of students that are found to be gifted in a particular field, such as science. Defining giftedness, however, is more challenging. Over the years, giftedness has been given many definitions (see e.g. Subotnik, Olszewski-Kubilius, & Worrell, 2011) and the complexity of finding a definition is seen in a book written in 1986 by multiple authors (Sternberg & Davidson, 1986). The book contained more than a dozen definitions for giftedness. Furthermore, two decades later, when a new edition of the book was published (Sternberg & Davidson, 2005) the number of concepts defining giftedness had only increased. Researchers have tried to categorize the perspectives there are on giftedness, coming up with at least five things that contribute to giftedness. These are intellectual ability (high IQ), emotional fragility, creative-productive giftedness, talent development in various domains, unequal opportunities and hard-work and practice (Subotnik et al., 2011).

As there are many viewpoints on what giftedness is, reaching a concensus is challenging. However, most researchers do agree that the definitions have some similarities, especially in the non-cognitive aspects (e.g. motivation, self-concept, expectations). Many of the concepts also note the importance of social aspects (e.g. environment, family background) and agree that giftedness typically correlates with performance (Sternberg & Davidson, 2005).

A gifted student can, therefore, be defined as someone who achieves well in a particular field, even compared to other high functioning individuals (Subotnik et al.,

2011). This, of course, is a simplification of the vast array of definitions on giftedness, and does not, for instance, consider motivation, which plays a role in future achievement (Subotnik et al., 2011). Furthermore, it does not distinguish between cognitive, non-cognitive and social aspects, which can all affect achievement. However, as any definition will have its limits, in this thesis gifted students refer to those students who are motivated to study science and have shown their motivation through achievements in and out of school.

Previous studies have shown that an ideal learning environment for gifted students supports holistic learning (Tirri, 2011; Tirri, 2012). This means acknowledging the students' academic, social and emotional needs, in essence, their personal growth (Tirri & Kuusisto, 2013). Research has shown that especially social support is important for gifted youth, as their educational outcomes can depend on whether their social environment value or devalue their academic efforts and achievements (Bliuc, Ellis, Goodyear, & Hendres, 2011). Receiving this social support from both like-minded youth and teachers is important (Tannenbaum, 1983). In addition to social support, gifted students require an advanced curriculum (Colangelo, Assouline, & Gross, 2004) that reflects their interests (Subotnik et al., 2011) and gives them the possibility to advance in their learning at a faster pace (Colangelo et al., 2004).

One way to support gifted students is through non-formal education (Tirri & Kuusisto, 2013). For instance, previous studies have shown that extra-curricular programs, such as camps, have a positive effect on gifted youth. Such programs can increase the quality of peer relations (Rinn, 2006), increase self-confidence, thinking skills, motivation and autonomous learning (Moon, Feldhusen, & Dillon, 1994). Furthermore, there are indications that these affects persist over time (Moon et al., 1994), though some researchers are more skeptical about the long-term effects, arguing that gifted students will achieve well, despite non-formal educational programs (see Hany & Grosch, 2007).

Though the positive effects of non-formal education on gifted students is noted, there is a limited amount of studies looking at what type of non-formal education is relevant to the gifted youth. This thesis sheds light on this issue through **Studies IV, V** and **VI**.

4. METHODOLOGICAL FRAMEWORK

This thesis combines characteristics of a ***descriptive research*** (see Cohen, Manion, & Morrison, 2008) and a ***case study approach*** (Cohen et al., 2008) with hints of a ***grounded theory approach*** (Denscombe, 2010). Characteristics of a descriptive research are clearly present, as this thesis uses surveys to describe students' points of view and attitudes towards sustainable development and its education. Simultaneously, characteristics of a case study are present, as it examines a particular non-formal learning environment, the Millennium Youth Camp, and uses this as a case to contribute to the discussion on the research problem. Grounded theory, on the other hand, is not used in its pure form, but rather, certain characteristics that were found useful for this thesis were "borrowed".

This chapter defines these three approaches, explains how they were used and why they were chosen. Furthermore, the last section of this chapter addresses the benefits and challenges of mixing different approaches.

4.1. Descriptive Research

Typically the main concern of descriptive research is to study beliefs, points of views, attitudes and effects being felt by the person/group under study (Best, 1970). The data is typically gathered at a certain point in time with the intention of describing conditions, identifying trends and patterns, or to determine the relationship that prevails between events (Cohen et al., 2008). Depending on the aim of the research, it can be approached using a variety of different research strategies, such as survey research, longitudinal studies, cross-sectional studies or trend studies (Cohen et al., 2008). In this thesis, the most commonly used methodology is survey research, but a longitudinal study is also implemented.

Survey research was selected as one of the research methodologies for this thesis, as it gives the possibility to collect a large amount of data at a specific point in time (Denscombe, 2010). Moreover, survey research works well when there is a clear and narrow target of what type of information needs to be obtained (Denscombe, 2010). In this thesis, this was the case with RQ1 and RQ3, which examine the type of questions and expectations students have about education for sustainable development before attending a non-formal educational program that deals with sustainability issues. Survey research was also partially used to examine how students' expectations can be met (RQ4).

The survey research conducted in this thesis used a non-probability sample that was "hand-picked" (see Denscombe, 2010) to collect the data. Regarding RQ3 and RQ 4, the decision to do so is clear, as a sample of students applying for a non-formal educational program was needed. However, with RQ1, the decision to do so may not seem so straight forward. Someone might argue that the sample does not represent a typical science class-room, as all the students in the sample are interested in science. In this, they would be correct, and the argument would be significant if the aim was to answer RQ1 quantitatively. However, in this thesis, RQ1 is mainly answered qualitatively, although

Study I does have a quantitative aspect to highlight that even students interested in science present a significant amount of non-scientific questions. The qualitative approach was chosen to contribute to the wider discussion on what type of teaching methods can be used to make education for sustainable development more relevant. From this perspective, a non-probability sample has its benefits. Namely, students interested in science can be assumed to present a wider range of different types of questions than students not interested in science. Therefore, a smaller sample was needed to get a good representation of the types of questions students ask.

Though descriptive research is beneficial for many purposes, it is not very useful in sensitive and complicated matters. As RQ4 had such elements, a case study approach was seen as an appropriate approach to dealing with these issues.

4.2. Case Study

A case study is a research approach that focuses on a single instance, or a phenomenon by trying to provide an in-depth view of the experiences, relationships and processes that occur in that instance (Denscombe, 2010). They are set up in a controlled environment, such as a school or a camp (Hitchcock & Hughes, 1995), and they aim to find principles from the case, which can then be generalized to other similar situations or cases (Robson, 2002). In other words, case studies often try to catch a close-up of reality by trying to portray "what it is like" to take part in a particular experience, and what kind of thoughts and feelings that might evoke in the person taking part (Cohen et al., 2008).

Case studies have several strengths compared to other research methods. These include catching unique features that may otherwise be lost in larger scale data. They are strong on reality, they help understand other similar situations and they can embrace unanticipated events (Niset & Watt, 1984). However, they also have their limitations. For instance, they are not easily cross-checked, causing possible personal and subjective bias, and the results may not be generalized except where other researchers and readers see their application (Niset & Watt, 1984).

In this thesis, a case study approach was used to answer RQ4, as an in-depth, holistic view of relationships and processes was the aim. The data was collected using observations (of documents) (**Study V**) and questionnaires (**Study IV & VI**). Out of the studies contributing to answer RQ4, **Study IV** is a case study in its' own right and together, **Studies IV, V and VI** contribute to describing the case from a wider perspective.

4.3. Grounded Theory

Grounded theory is a research approach that aims to create a theory based on data collected from the field, contrary to the more common method of first creating a theory on the abstract level and then testing it in practice (Denscombe, 2010). Though grounded theory has been used in many ways since its first creation in the late 50's and early 60', by

Glaser and Strauss, some general principles do exist. First, in a grounded theory approach, data collected from the field is analyzed without trying to fit it into an existing theoretical framework. Rather, the researcher should keep an open mind when analyzing the data to see if something new and unexpected emerges. Only after the data is analyzed and interpreted, are the findings compared to existing research. If a new theory emerges from the data, more data is collected to test the results (Denscombe, 2010). Therefore, grounded theory is not a theory as such, but rather, an approach to generate a theory from data (Bryman, 2008).

Due to its characteristics, grounded theory is typically quite adaptable and pragmatic and is especially useful in systematically analyzing qualitative data, as well as formulating theories from the data collected (Denscombe, 2010). However, one of the major challenges is that precise planning of grounded theory research is difficult (Denscombe, 2010). Furthermore, it requires the researcher to be open-minded to new ideas, as there should not be any theoretical framework guiding the analysis of the data. This has also caused some to criticize the approach as "empiricist", as it does not acknowledge the complex nature between theory and data collection, but rather, assumes that the explanation is in the data and is only waiting to be "discovered" (Denscombe, 2010).

In this thesis, **Studies II** (RQ1) and **III** (RQ2) use elements of grounded theory, though neither of the studies use the methodology in its purist form. In **Study II**, data was collected using a questionnaire and analyzed with inductive and deductive qualitative research. Some of the categories formed in the analysis were based on previous research (deductive), but most of the categories were new. Only after discovering the categories, other research supporting the categorization was found. However, as the formed categories were not tested again through field work, the final stage of a grounded theory approach was not completed. In **Study III**, the data was collected through unstructured interviews, and again, the data was analyzed using inductive and deductive content analysis. Only when analyzing the interviews, did the researchers start to realize the trends depicted in the study. These trends were then used to create a theory, which was compared with other similar research. The researchers then analyzed more data (though new data was not collected) to strengthen their findings. Again, the stage of collecting new data was omitted in this study, and therefore it does not meet all the criteria for a grounded theory approach. Regardless, both **Study II** and **III** of these studies benefitted from using parts of the grounded theory framework.

4.4. Mixed methods research and triangulation

As is done in this thesis, it is not uncommon to use several different research approaches within a single research project. Mixing different approaches can help overcome many of the problems of using only a single approach, such as bringing completeness to an issue of interest, answering several research questions simultaneously and helping explain the results obtained in a more in-depth way (Bryman, 2008).

Mixing methods can be accomplished done in several ways, such as mixing several qualitative or quantitative research methods (Denscombe, 2010). However, only when both qualitative and quantitative methods are mixed together, is a research said to have a ***mixed methods research approach*** (Bryman, 2008). This thesis does this by implementing some quantitative data (**Study I and Study V)** to support the qualitative data. However, as most of the studies in this thesis are of qualitative nature, the scale between quantitative and qualitative data is skewed, and therefore other ways to increase the reliability of the results are also used.

When a study examines things from more than one perspective, but does not necessarily do so by analyzing both qualitative and quantitative data, the process is called triangulation (Denscombe, 2010). This thesis uses three ways of triangulation, namely, methodological triangulation, time triangulation and investigator triangulation (Denscombe, 2010). These are used in order to the improve accuracy of the results as well as provide a more complete picture on the topic. More information on how triangulation is used, is explained in the next Chapter and the studies themselves.

5. DESCRIPTION OF THE STUDIES

This chapter describes the six studies that construct this thesis. The chapter is divided into four parts according to the four research questions.

The first part presents two studies (**Studies I & II**) that examine the type of questions students ask about ESD. The second part presents **Study III**, which looks at the kind of actions students take in order to make the world a better place. The third part presents **Study IV(a)**, which examines the type of expectations students have when applying to a non-formal educational program with a focus on sustainable development. The final section presents three studies (**Studies IV(b), V and VI**) which examine how non-formal can help meet the educational expectations of students.

The data collected for all of the six studies has a relation to the Millennium Youth Camp (MYC). The MYC is an international camp that has been held in Finland once a summer in 2010-2014. The attendees of the camp are 16-19 -year old students from all around the world. The campers are selected through a rigorous three stage selection process, with the following stages: In ***stage 1***, students describe their previous science related accomplishments, present questions to which they would want answers during the camp and write about their motivation towards science and applying to the camp. The top 100-200 applicants are then selected for ***stage 2*** of the application in which students have to complete an individual project work on a specific theme assigned to them by specialists. These projects are related to the students' areas of interest, presented in stage 1. In ***stage 3*** the candidates with the best projects are interviewed and the final selection is made. The selected campers (30-60 students) then start to work on a group project online, two months before the camp. This process is guided by a specialist from a university or a private company. During the camp, attendees continue working on their project, as well as attend many other kinds of activities (see **Study V** and **VI** for more details).

The data used in this thesis was collected through self-completion questionnaires, essays and interviews and was analyzed using both quantitative and qualitative content analysis, as is presented in the following sections.

5.1. Students' Questions on Sustainable Development

For student-centered learning to be successful, it must have an interesting problem or question to tackle (Pedersen & Liu, 2003). However, research on students' interests on themes related to sustainable development is scarce, if non-existent. Therefore, in order for ESD to move to more student-centered approaches, studies on student interest are called for. That said, it is not so important to know whether or not the students are interested in ESD in general, but rather, to know what aspects of the issue they find relevant. In order to start this examination, two studies were conducted on students' questions on sustainable development and presented in this section. **Study I** looks at questions students ask about sustainable development from a broad perspective, whereas **Study II** looks at questions asked about climate change in specific.

This section first presents how the data for these two studies was collected and analyzed. It then discusses the results and goes on to summarize the key findings. The contribution of these two studies to the research problem of this thesis is discussed in Chapter 7.

5.1.1 Data collection and analysis

Study I used deductive content analysis to examine the type of questions students ask about sustainable development. The data was collected from the first stage applications to the 2011 MYC. In the application, students were asked to select one of the following five theme groups to which they wished to apply: *Climate change, Renewable energy and resources*, *Water*, *ICT* and *Applied mathematics*. As this study focused on the type of questions students ask in a context of natural science, and more specifically, on sustainable development, the applications for the *ICT* and *Applied mathematics* were omitted from this study.

The students applying to the *Climate change, Renewable energy and resources*, and *Water* groups were asked to present questions to which they would want answers during the camp. The questions presented by applicants from Europe and Asia (N=544) were analyzed through deductive content analysis. The questions were categorized into scientific, societal and moral questions. Some questions presented by the students held two or more of these dimensions within them and so, a ranking system was formulated, making it possible to categorize each question into only one of the three dimensions (see **Study I** for more details).

To assure the reliability of the analysis, a sample of 100 questions was analyzed into the three categories by a researcher not involved in writing the paper. These results were then compared to the analysis of the authors. The inter-rater reliability (ir) between the two researchers was calculated with the formula:

$$(2) \quad \text{ir} = \frac{\text{n of rater agreements}}{\text{n of questions}}$$

The level of agreement was found to be reasonable (ir=0.83). The categorized questions were then analyzed using non-parametric statistical methods and cross-tabulated with gender (male/female), continent of origin (Asia/Europe) and camp themes (climate change/renewable energy/water). Analysis was done using *IBM SPSS Statistics 21*.

The reason for using a quantitative approach in **Study I** was to first get a broad understanding of the type of questions students ask in a science context. As students were expected to ask a wide range of questions, it was rationalized that a quantitative approach would provide an initial understanding on how relevant students find the types of questions presented. Though **Study I** gave room for inductive content analysis, it was guided by deductive content analysis, as the groups formed stemmed from previous theory of the type of aspects students find relevant. The deductive content analysis also affected the descriptions of the three groups formed in **Study I**, namely, academic, societal and moral interests.

To answer RQ1 in more depth, more information was needed on the different types of questions observed in **Study I**. **Study II** was carried out for this purpose. **Study II** analyzed the questions of students applying to the MYC Climate change group (in 2011). Applicants from Asia and Europe (n=200) presented 355 climate change related questions, which were examined with deductive and inductive content analysis. In the analysis, the questions were categorized into five groups and the reliability of the descriptions of the groups was tested by a researcher not participating in writing the paper. This was done by giving the external researcher the descriptions of the five groups and asking them to categorize a randomly selected sample (10%) based on the descriptions. Their analysis was then compared to the analysis of the first author by using Cohen's kappa analysis:

$$(3) \quad \kappa = \frac{Pr(a) - Pr(e)}{1 - Pr(e)}$$

where Pr(a) is the observed agreement between the researchers and Pr(e) is the expected level of agreement if agreement happened by chance (Cohen, 1960). The Cohen's kappa coefficient κ was calculated using *IBM SPSS statistics 21*. The agreement between the two researchers was found to be good (K=0.82). Furthermore, correlation between the obtained groups was analysed and the difference between gender, continent of origin and age were analysed with the Mann-Whithey U-test.

5.1.2 Results

Study I found that students mainly ask scientific questions (57%) in issues related to sustainable development, but that societal (23%) and moral (20%) questions were also common. The nature of the questions differed depending on which theme group the students applied to, but consistencies between the theme groups were also found. For instance, in both the climate change and water group, students were concerned about global effects.

From the scientific issues, students were most typically interested in the relation between scientific discovery and technological developments, as well as how scientists do research, and how the quality of the research and findings are tested. Scientific questions were more common among male than female students. The students' societal questions showed that students want more information on how countries co-operate and make global decisions in issues such as the use of renewable energy and climate change mitigation. The societal questions also echo a concern for the overuse of natural resources. Female students were more inclined to ask societal questions than male students. The typical moral questions showed a concern for the planet and a willingness to take action to solve environmental problems. More commonly, the moral questions were related to what individuals can do, but some students also asked broader questions, with a societal dimension such as, what societies could do to make the world a better place.

Study II brought more depth to students' questions by examining the type of questions asked about climate change. The analysis of students' questions showed that students are interested in a wide range of climate change related issues, which can be categorized into

five main groups: *Climate System Framework* (33%), *Effects on Humans* (11%), *Solutions for Climate Change* (37%), *Raising Awareness* (6%) and *Human Action* (13%). The questions categorized into the *Climate System Framework* group showed that students want further understanding in the science of climate change, and furthermore, they want to understand how science is done (the Nature of Science, NOS). The questions also showed that students want to understand how to examine the trustworthiness of scientific findings.

Students also wanted to know how the changing climate will affect humans, both societally and economically. They also showed great interest in knowing more about what can be done to combat climate change. Most of these questions were directed at individuals, but some questions were more societal, pondering how to increase the use of renewable energy, for instance. Related to these questions, were those where students asked what governments and societies are already doing to combat climate change (*Human Action*). In addition, some students also found it important to learn how to raise the awareness of others.

5.1.3 Summary

The aim of **Study I** and **Study II** was to find out what type of question students ask about sustainable development in general and climate change in specific. **Study I** examined the issue mainly from a quantitative perspective, whereas **Study II** provided qualitative insight. The findings of these two studies have many similarities, as both reflect the fact that students ask a wide range of scientific questions related to sustainable development and climate change. Both studies also show that students ask a wide range of societal questions, and often have moral issues embedded into their questions. The quantitative analysis of **Study I** shows that academic (57%) questions are most popular, but that students also ask societal (23%) and moral questions (20%). The qualitative analysis of **Study II** shows that students' questions on climate change can be analysed into five distinct groups, namely: *Climate System Framework* (33%), *Effects on Humans* (11%), *Solutions for Climate Change* (37%), *Raising Awareness* (6%) and *Human Action* (13%). The findings of the two studies give insight into what type of problems students will find interesting to grapple with in science class.

5.2. Students' Actions to Make the World a Better Place

As was presented in the introduction, implementing citizenship education into science education has already started to take place. However, defining "good citizenship" is difficult, or maybe even impossible (see **Study III** for more discussion). Regardless, it is beneficial to consider how students' view citizenship and what type of actions they take as citizens, regarding sustainable development. To gain understanding on this, **Study III**, presented below, examines what type of actions students are already taking as participatory citizens and how knowledge on these actions can be used to improve science education.

5.2.1 Data collection and analysis

In **Study III,** 35 students selected to the 2013 Millennium Youth Camp were interviewed, with the aim of finding out what type of actions students are taking to make the world a better place. The interviewed participants came from all corners of the world, representing 21 different countries.

The interview questions were developed by the researchers through two pretests, one conducted on pre-service teachers and the other conducted on 16-18 year old students from a prestigious high-school in Helsinki, Finland. Through discussion and testing, the researchers developed the interview questions to best answer the research question. Themes of the interview included:

- *Can humanity solve the problems it is currently facing?*
- *Who is responsible for solving these problems?*
- *How do the students themselves contribute to solving these problems?*

(see **Study III** for more details)

After the interviews were transcribed, the data was analyzed in two phases. In the first phase, the data was analyzed using inductive content analysis to reduce the content into categories. In the second phase, these categories were organized to form conceptual categories using both inductive and deductive content analysis. As a result, the data was categorized into three conceptual categories, described in the Results section.

To ensure reliability in the grouping, two researchers independently analyzed the transcripts of the interviews using the descriptions of the three conceptual categories that were created based on the first round of analysis. Inter-rater reliability was tested with Cohen Kappa (see section 5.1.1), showing that the reliability of the categorization was good (K=0.80-0.88).

5.2.2 Results

Study III shows that students take various actions in order to make the world a better place. These actions can be divided into three types, namely: personal responsible actions, participatory actions and preparation for the future.

Personal responsible actions refer to actions that students take on a personal level, such as helping friends, recycling and giving money to charity. The majority of students interviewed were doing some sort of personal responsible actions. The reasons to take personal responsible actions were typically due to virtues, such as kindness and honesty or due to societal responsibility. Some students also said they did these actions in the hopes of influencing others to do the same.

The majority of the students involved in the study were also making the world a better place though participatory actions, which refers to actions where students organized or participated in events and community efforts. Common examples of participatory actions included participating in fund-raisings and volunteering for different organizations.

Students participated in such actions to raise-awareness and help others, as well as to learn how to successfully carry out such projects and to get to know new people.

Additionally, the study found that students are taking steps to make the world a better place in the future (i.e. preparing for the future). For instance, students were studying hard in order to get a certain degree or job they saw as beneficial to society (e.g. medical doctor or engineer), and they were networking with peers and experts. The rationale that students presented for their future oriented actions were that they believed that development in science and technology would be the most efficient way to make a positive impact on the environment.

5.2.3 Summary

The aim of this study was to find out what 15-19 year-old students interested in science and sustainable development are doing to make the world a better place. The analysis focused on students' behaviour, as well as their intentions and motivations for their actions. Three categories emerged from the analysis, showing that students take personally responsible actions, participatory actions and actions that prepare them for the future. Most students were involved in more than one of these actions (see table 2 in **Study III**).

According to this study, students see themselves as future citizens or citizens-in-the-making, but also as citizens of today, who are actively participating in making the world a better place. This view is slightly different than the views presented previously, where young students are mainly perceived as future citizens (e.g. Alderson, 2000; Levinson, 2010). The findings of this study also have resemblance to a study conducted by Westhemer and Kahne (2004), in which they highlight different types of citizenships from an educational perspective. However, the difference is that this study describes how students actually behave as citizens, both in and out of the school environment (See **Study III** for more discussion on the differences).

5.3. Students' Expectations of Non-Formal Education within a Context of Sustainable Development

Previous research has shown that an ideal learning environment for gifted students supports holistic learning (Tirri, 2011; Tirri, 2012), meaning it supports their academic, social and emotional needs (Tirri, Kuusisto, & Aksela, 2013). Gifted education should also be provided with an advanced curriculum (Colangelo et al., 2004) that reflects students' interests (Subotnik et al., 2011) and gives them the possibility to advance in their learning at a faster pace (Colangelo et al., 2004).

To contribute to the discussion on what gifted students expect from their education, this section presents **Study IV(a)**, which analyses the type of expectations students have when applying for a non-formal educational program that focuses on sustainable development from a science, technology, engineering and math (STEM) perspective.

This section will first present how the data for the study was collected and analyzed; and then present the key results and give a summary of the findings.

5.3.1 Data collection and analysis

For the benefit of the reader, in this thesis, **Study IV** is divided into two parts. The first part, referred to as **Study IV(a)**, analyzed what type of expectations students have when applying to an international non-formal educational program. The data for this section of the study was collected during the first stage of students applying to the 2010-2011 Millennium Youth Camp (see beginning of Chapter). The 1 935 applicants presented a total of 4 348 open ended expectations for the camp, which were grouped through qualitative content analysis by the first author of the study. Inter-rater reliability of the grouping was tested by having an outside researcher analyze a hundred of the expectations and categorize them into formed groups using the group descriptions created by the first author. The inter-rater reliability was calculated using Formula 1 (see section 4.1.1) and was found to be good (ir=0.83). The second part of the study, referred to as **Study IV(b)**, analyzed how the students' academic, social and ethical expectations were met and will be described in section 4.4.

5.3.2 Results

The results of **Study IV(a)** show that when applying to a science non-formal educational program most students have academic (90%) and social (68%) expectations and over a third (38%) of the students have ethical expectations.

Students' academic expectations focus on wanting to learn more to satisfy their curiosity in science and to succeed in school. Students also expected to learn skills for doing their own research. Some students also wanted to know more about the Finnish academic system and compare it to that of their home countries'. Students' social expectations focus on wanting to meet new people from different parts of the world, share ideas with like-minded youth and make new friends. Some of the students also expected to get to meet and talk to renowned scientists. Ethical expectations showed that students wanted to learn how they can make a difference in the world and influence others to do so as well. These expectations also showed that students want to learn more, in order to be able to make a difference in the future.

One-fourth (24%) of the students asked both societal and ethical questions. As these questions were related to each other, a composite variable, called socio-ethical expectations, was formulated. These expectations typically focused on finding a group of peers from the camp, who would be interested in working together on an ethical project, such as raising awareness on climate change.

5.3.3 Summary

The aim of this study was to find out what type of expectations students have when applying to a non-formal educational program interested in science. **Study IV(a)** found that students have many academic, social and moral expectations. They want to attend non-formal education to satisfy their curiosity as well as to make new friends and participate in meaningful (ethical) discussions. The results coinside with previous findings, although differences are also discussed in the paper.

5.4. Non-Formal Education Meeting Students' Needs and Expectations

As was highlighted in the previous section, gifted students have high expectations from their education in general and non-formal education in specific. This chapter presents three studies that aim to answer the fourth research question: How non-formal education is meeting students' needs and expectations?

First, **Study IV(b)** continues from where the previous section left off, by presenting how project works assigned by specialists contributed to meeting students' needs. **Study V** examines how well non-formal education meets the expectations for relevant education. **Study VI** then examines students' experience of the camp to find out how well the program meets their expectations.

Similar to the previous sections, this section also consists of three parts. The first part introduces the way the data for the three studies was collected and analyzed. It also presents the goals of the camp, used in the analysis of **Study IV(b)** and **V**. The second part discusses the main results of the studies and the final part summarizes the key findings.

5.4.1 Data collection and analysis

Study V examines the relevance of three different non-formal educational programs, one of these programs being the Millennium Youth Camp. To analyze the relevance of the camp, the study examined the relevance of the general goals of the camp as well as the goals set for the project work.

The general goals of the camp were:

- Encourage 16–19 year olds to study mathematics, natural sciences, and technology,
- Introduce students to the academic and professional opportunities that Finland has to offer in the areas of mathematics, natural sciences and technology, as well as help strengthen the image of Finland as a great country in which to come to study and work,
- Make the Millennium Technology Prize better known,

- Help the youth network with each other
- Provide students with opportunities to meet researchers and stakeholders in Finnish companies and organizations, and
- Provide the youth the opportunity to have fun with like-minded youth and enjoy their experience in Finland.

The goals for the project work were:

- The projects are related to sustainable development,
- There should be more than one right answer to the research question,
- The projects should encourage students to think creatively, and
- The projects should deal with an ongoing discussion between science and society.

Each goal was categorized into one of the three dimensions of relevance (individual, societal and vocational) by two researchers. The categorization of the researchers were then compared and it was found that eight of the ten goals were categorized into the same dimension of relevance (ir=0.80) (see Formula 1). The researchers then discussed the discrepancies in the analysis and agreed that not enough information was provided on the two goals they had categorized into different groups. Through the discussion they realized that the categorization of these two goals depends on whether the goal is viewed from a students' point of view or from society's point of view.

In **Study IV(b)** five specialists working at the Millennium Youth Camp filled out an online questionnaire on how well they felt they were able to implement the goals of the camp curriculum into their coaching. The questionnaire included questions on which and how curriculum goals had been implemented. The specialists were also asked to describe additional goals they had set, if they had done so. The specialists gave specific examples for each of the questions in the questionnaire. In the pre-analysis of the data, two researchers individually drew out themes that were present in the answers of the specialists. The reliability of the derived themes was then discussed by the two researchers and some themes were dropped, while others emphasized until the two researchers found a mutual agreement on the themes.

In **Study VI** a questionnaire was given to the attendees of the Millennium Youth Camp immediately after the camp (**part A**) and one year after attending the camp (**part B**). The data for **part A** was collected after the 2010-2012 camps. All the participants of the camps (n=88) answered the questionnaire. In the questionnaire, the participants were asked to write about the highlights and the areas of improvement of the camp. These open-ended answers were analyzed by content analysis and the inter-rater reliability of the groups was tested using Kohen's Kappa analysis (see Formula 2). The inter-rater reliability was found to be excellent (κ=0.94). In **part B**, students of the 2010-2011 camps were asked to write an essay about their camp experience one year after the camp. Half of the campers (n=30) wrote and submitted the essay. Researchers analyzed these essays to find out what kind of long-term effects the camp had on the attendees. Content analysis revealed eleven distinct long term effects. The descriptions of these effects were given to the authors of the essays. The authors were then asked to analyze which of these effects they find in the essays they had written. The level of agreement between the authors and the researchers were

analyzed using Cohen's Kappa analysis, and the agreement was found to be excellent (κ=0.91).

5.4.2 Results

The results of **Study IV(b)** show that the specialists were able to implement different types of academic goals into the camp. The specialists all agreed that the camp provided a chance for students to increase their knowledge in science. Furthermore, some of the specialists mentioned that the camp gave students the opportunity for creative thinking, learning about academic and professional opportunities, and gaining new experiences in STEM subjects. The specialists also found that the camp curriculum met the social goals set for the camp. They found that the camp helped students network with each other, meet experts and have fun with each other. Also, some of the specialists noted that although they did not see much of the social activity taking place during the camp, they noticed that the students were connecting well with each other. During the project works, guided by the specialists, four out of five of the groups also got to deal with ethical issues, namely through socio-scientific discussions. This was accomplished by careful selection of the topic of the project, as well as the specialists leading conversations towards socio-scientific issues. The specialists also mentioned that many of the groups had the opportunity to deal with ethical issues while discussing environmental aspects of their projects.

The results of **Study V** showed that the ten goals set for the Millennium Youth Camp contain all three dimensions of relevance. The two researchers agreed that individual relevance was most strongly present in the goals of the camp. They saw the camp contributing to student's individual relevance by helping youth network with one another, having fun with like-minded youth, presenting research problems that do not have a single right answer and by giving students' projects that encourage creative thinking. Furthermore, projects that deal with sustainable development and socio-scientific issues add to students' societal relevance.

Vocational relevance was provided by introducing future academic and professional opportunities and giving students the opportunity to network with science experts. Alhough the researchers initially disagreed to what area of relevance two of the goals contribute to, after discussing the goals, the researchers agreed that the goals can be categorized into two areas of relevance, depending on the point of view. The two goals which were more thoroughly discussed were *encouraging students to study STEM subjects* and *making the Millennium Technology Prize more known*. These can be seen to contribute to societal and/or vocational relevance, depending on whether they are viewed from the perspective of the student or society.

The results of **Study VI(a)** showed that student's expectations of the camp were met as they enjoyed a wide range of social and academic activity during the Millennium Youth Camp. The students enjoyed the possibility of getting to know like-minded people interested and gifted in science. They were especially glad that the camp program gave them the opportunity to get to familiarize each other with their backgrounds and cultures.

In addition, campers enjoyed meeting and discussing science with experts. They found these encounters inspiring and motivating. The students also enjoyed other social activities, such as the sauna nights, touring the city and the welcome party, but these were not highlighted as strongly as the activities that gave students more meaningful encounters with others.

The results also showed that students interested in science like a wide range of academic activities. Students especially enjoyed visiting universities, where they could visit laboratories, talk to experts and work on their projects. Students also enjoyed visiting companies, which provided similar activities as did the universities. In addition to these, students mentioned a wide range of other academic activities they enjoyed. The diversity of activities enjoyed shows the diversity of students, which should always be taken into consideration when planning a non-formal program for students.

Study VI (b) showed that meeting the students' expectations impacted their lives well into the future. The greatest impact (87% of students) was in the way that students saw themselves and the world around them. For instance, students mentioned that the camp had increased their motivation and self-confidence. The camp also opened students' eyes to see the world around with a wider perspective, and all the possibilities that this offers. These changes in perspective, also had an academic impact on the students, as their view on education and their future had changed. A few even mentioned that attending the camp had a direct effect on them getting into a school or being accepted to an internship. Even a year after the camp, students continued keeping in touch with other camp participants, feeling that the camp had met their social expectations, as it had provided them with friends from all parts of the world. Some even said that it was the first time they felt appreciated for the things for which they had a passion.

5.4.3 Summary

The three studies presented in this section aimed to find out how non-formal education can be made relevant to meet the students' needs. **Study IV** showed that a variety of educational goals meeting the three dimensions of relevance can be implemented into projects that are given to the students. These projects should be centered on students' interests. **Study V** showed that by having sustainable development as a context in a non-formal educational program, the goal will meet expectations of societal relevance. Individual and vocational relevance can also easily be implemented into non-formal education. **Study VI** discussed the different academic and social activities that students find to be a meaningful part of non-formal education. Combined, the three studies give useful insight on how non-formal education can meet the needs and expectations of students.

6. VALIDITY AND RELIABILITY

This chapter discusses the validity and the reliability of this thesis by examining the research approaches and methods used. Some of this discussion has already been embedded into the previous two Chapters, so the main focus of this chapter is to examine how well the selected research approaches answer the research questions, and hence, the research problem, despite the methodological limitations that were presented in Chapter 4 and **Studies I-VI**.

It is clear that every research method and approach will have its limitations. Therefore, it is crucial to examine how well the research has answered the research problem and whether the same results would be obtained if the experiments would be repeated. Discussion of the validity and reliability of this research are used to examine this.

Validity refers to how accurately a study is able to measure what it has set out to measure (Cohen et al., 2008). Validity can be divided into external and internal validity. External validity refers to how well the results of a study are able to be generalized or transferred, whereas internal validity refers to how vigorously a study is conducted, how well the data supports the discussion and how well alternative explanations for the results are taken into consideration (Cohen et al., 2008).

To discuss the external validity of this thesis, scrutiny is needed of the specific methodologies chosen. Many qualitative studies are not conducted to provide generalizations, but rather to provide transferability. Such is the case in this thesis. Data collected from students who are gifted in science cannot be generalized to students in a regular classroom; nor can the questions asked by students who are interested in science and sustainable development. Therefore, due to the qualitative nature of this thesis, most of the data is not directly generazible to classrooms. However, due to the multiple methods used in collecting and analyzing the data, the results are generalizable to other similar groups of students, namely gifted students or students interested in science. Furthermore, the data is transferable to classroom settings, as any given classroom will typically have students who are gifted in science or interested in sustainable development. The transferability is further increased by using a mixture of descriptive research methodologies and case studies. For instance, in this thesis, descriptive research gives a broad perspective on how students' expectations for non-formal education were met, whereas the case studies look more into the intricate details of the same issue.

The internal validity of the thesis was enhanced through several means. First, the studies were conducted over several years from a relatively large number of participants. Some of the studies also consisted of longitudinal research. Furthermore, the methods used to collect and analyze the data have been described in detail in **Studies I-VI**, bringing clarification to the research approaches used. When combined, these factors increase the internal validity of the research, as they highlight that the studies were designed with care and transparency.

The validity of the content also affect the validity of the thesis. In the studies presented in this thesis, content validity was increased by collecting data anonymously from the students (when possible) and by not telling them the research interests of the researchers. This was done in order to avoid students from answering questions the way they thought

the researchers would want them to be answered. However, it is reasonable to say that this could not be avoided completely. First, the students applying to the camp may have presented certain types of questions to impress the reader. Secondly, the interviewed students may have tried to impress the researchers with saying they take environmentally friendly actions, whereas in reality, their actions may have only been environmentally friendly behavior (see Jensen & Schnack, 1997). Due to the nature of the methodologies used in this thesis, it has been necessary to assume that the participants are honest in their answers. This same assumption applies to most research in education and social sciences. The way to overcome this challenge would be to conduct observational research (e.g. ethnographic research), but such research would have not been the most efficient way to answer the research questions of this thesis. To reduce the possibility of students being dishonest, content validity was increased by collecting data over time (time triangulation) and by collecting data from a large sample of students.

In addition to validity, a well conducted research needs to examine the reliability of the results. This means that the extent to which experiments can be repeated to obtain the same results needs to be considered (Cohen et al., 2008). In this thesis, the reliability was assured though a number of ways. The first factor influencing the reliability of this thesis is that the data was collected over a period of time, and the data collected from different years pointing towards the same results and conclusions. Furthermore, the thesis used different ways to examine the same research question. This is seen in RQ1, in which two distinct ways of analyzing the students' questions on sustainable development and climate change still show that there is resemblance in the results. Different research methods were also used to examine RQ4, all methods pointing to the same conclusions.

Most importantly, the reliability of the studies presented in this thesis was increased by inter-rater reliability, which was used in several ways, as seen in Chapter 5. Using peer assessment on the analysis gives confidence that the data was categorized in a reliable way and that the data analysis could be replicated in future research as well. Furthermore, inter-rater reliability helps overcome some of the limitations of case studies, namely, the subjectivity of the results (Cohen et al., 2008).

To conclude, this thesis has overcome many of the common challenges related to validity and the reliability by using triangulation and a mixed methods approach. As with all qualitative research, generalizations of the findings must be made with care, but the transferability of the findings are on a solid foundation. Furthermore, this chapter gives sufficient arguments and examples to claim that the internal validity of the research has been considered extensively. Through out the research, sufficient measures have also been taken to ensure that the content used is valid. Finally, the reliability of the findings has been examined from multiple perspectives and the inter-rater reliability has been checked in all of the studies. In sum, this thesis has considered multiple aspects of validity and reliability providing a foundation that the data and the results of this thesis are trustworthy.

7. DISCUSSION AND CONCLUSIONS

This thesis examines the multifaceted research problem of "**what do international youth find relevant in sustainable development and its education"**. This research problem was examined using several research methodologies, namely descriptive research, case studies and elements of grounded theory.

The research problem was set on the assumption that students do not find science education to be relevant (see e.g. Hofstein et al., 2011; Osborne & Dillon, 2008), and that sustainable development, with its multidisciplinary issues, has the potential to bring relevance to science education (e.g. de Haan, 2006). It also acknowledges that earlier research on students' perspectives on sustainable development and its education are lacking. Using this knowledge as a baseline, this thesis set out to examine students' perspectives on sustainable development, in order to contribute to the discussion on how ESD could be used to make science education more relevant.

As mentioned in the introduction, answering the multifaceted research problem is not a simple task. One reason is that 'relevance' can be understood in many ways, as has been discussed by Stuckey et al., (2013). Relevance can depend on a students' motivation and interest towards the topic, the relevance of the topic to society now and in the future, and the understanding of how knowledge about the topic will help students make decisions as future employees and citizens (see Stuckey et al., 2013). Though not the only solution to the problem, Eilks and Hofstein (2014) have discussed how bringing ESD into chemistry education can provide individual, societal and vocational relevance to the students. For this reason, this thesis examines students' perspective on the issue in order to provide a deeper understanding of what possibilities ESD can provide. Furthermore, this thesis relates the discussion to different educational approaches, with the aim to make education holistic, taking into consideration students' academic, social and emotional needs (see Tirri et al., 2013).

This thesis contributes to answering the research problem through four research questions related to the issue. RQ1, RQ2 and RQ3 focus primarily on giving a picture of students' perspective on ESD, whereas RQ4 focuses more on providing a model on how students' needs could be met.

7.1. Students' Questions on Sustainable Development

The findings from the first research question *"what type of questions do students ask about sustainable development?"* shows that when dealing with sustainable development, students want science education to provide a societal and ethical perspective, in addition to the more common academic perspective. The importance of discussing societal and moral issues in science education has already been emphasized by many educational researchers (e.g.(Burmeister & Eilks, 2012; Hodson, 2008; Juntunen & Aksela, 2014; Ratcliffe & Grace, 2003), but from the two studies presented here, it is seen that dealing with sustainable development from a holistic point of view is especially

important for the students. It is also note-worthy that students want to learn more about issues, such as the trust-worthiness of the media and scientific research, giving further support that socio-scientific issues and the nature of science should be discussed to make science education more relevant for the students.

As students show interest in wanting to learn more about complex societal and moral issues in a science context, the findings imply that even if education were to move further towards a student-centered approach, many of the important societal and moral aspects of sustainable development would be addressed by the students. Maybe even more so, as teachers may be incompetent to teach such issues (e.g.Ocal et al., 2011; Papadimitriou, 2004). Their teaching may be affected by their own world view (Lombardi & Sinatra, 2013). Furthermore, allowing students to address their own questions could help the students stay motivated (see Pedersen & Liu, 2003), as they find the questions to be important. This can also increase students' life-long learning skills and critical thinking skills (see Cornelius-White, 2007),

From a teacher's perspective, understanding the type of questions students ask can help the teacher address the students' interests and give greater understanding to their stage of development, thus, helping teachers differentiate students based on their interests. Expectedly, this should have a positive impact on the students' individual relevance.

However, it is important to note that the findings here may give a biased view on the type of questions asked in a typical classroom on a topic related to sustainable development. The reason for this is that the data in this study was collected from students interested in sustainable development and climate change. Due to their interest, they have most likely studied the issues in more detail than other students, and therefore, ask very diverse questions. However, this does not mean that these results are irrelevant to classroom practice. On the contrary, understanding the diversity of questions that students may be interested in helps the teacher moderate classroom discussion and guide the conversation towards the topics that have not yet been discussed. Guided discussions may even help students realize the topics they are interested in, but have not been able to articulate. Unfortunately, due to the nature of the studies here, this thesis is only able to give a hypothesis on how student-centered education could be incorporated into classroom practice and acknowledges that further practical research is needed.

To conclude, **Studies I** and **II** imply that it is reasonable to further examine the possibilities of student-centered education that stems from students' questions. Pre-service and in-service teacher training should focus on providing teachers with the tools to use students' questions to start relevant discussions and project works. Furthermore, teachers should be made aware that, as the topics are multidisciplinary, they may be incapable of answering all of the students' questions on sustainable development. However, this can be overcome by using various pedagogical methods been discussed in this thesis.

7.1. Students' Actions

The second research question, *"What type of actions do students take to make the world a better place?"* builds on the rationale that action competence is an important

aspect of ESD (e.g. Mogensen & Schnack, 2010), and more generally, citizenship education (Hitchcock & Hughes, 1995). As educators understand the type of actions students' are already taking, they can use that knowledge as a way to approach issues on sustainable development. Furthermore, by building on students' experiences and making a connection to their everyday lives, education can be made more relevant (see Stuckey et al., 2013).

Since students see themselves as citizens of today and the future (see 4.2.3), education should focus on what a citizen can and should do to take action on important issues. The context of sustainable development presents many such important issues which require action from citizens. However, if only certain beneficial actions are presented to the students, this may not increase action competence, but rather, would be a behavioral change (see Jensen & Schnack, 1997). Therefore, it could be more beneficial to build on the actions in which the students are already engaged. For instance, students could evaluate their actions from an environmental, societal and economical perspective and analyze what type of actions would be most beneficial. Such discussions among students or with a teacher could increase students' critical thinking skills, as well as self-awareness (Cornelius-White, 2007). Furthermore, education could provide students with more opportunities to take action by allowing them to plan and execute different types of actions with peers and experts, for instance, in a non-formal education context. Though such an approach does provide many benefits, the danger is that ESD becomes too centered on a single action, even though it should be holistic. Therefore, concentrating on students' actions should only be seen as one means to bring relevant ESD into learning.

Another way to incorporate students' actions into ESD is to take action competence into consideration in student assessment. For instance, when taking part in different projects in informal or non-formal settings, students are constantly learning about a topic. The knowledge and experience gained are relevant for the students, but a traditional educational system does not take such learning into consideration in the assessment of the students, even though they might be very meaningful to their future lives and careers (see **Study VI**). Of course, assessing action competence is challenging, as there isn't any "right actions", just as there are no "right answers" to socio-scientific issues (e.g. Abd-El-Khalick, 2003; Ratcliffe & Grace, 2003). However, some tools do already exist on how action competence could be assessed (Wood, 2015) and how future research should concentrate on creating more useful tools for a science education context.

The findings of **Study III** are compelling in that they show that students actively take action and by so doing, show action competence. These findings seem to be an anomaly, as previous research has shown that students are not usually willing to take action, even though they see an action as the morally right thing to do (Sternang & Lundholm, 2011). Therefore, future research should look deeper into why certain students are more willing to take actions than others. Previous research has shown that gifted students tend to have a higher level of moral judgment than their peers (Narváez, 1993), this being a possible reason for the anomaly, though most likely, not the only reason.

7.2.1 Action Competence

One of the main challenges in ESD is to empower students (Juntunen & Aksela, 2014) and to help them become action competent. Previous studies on the issue have described what action competence is and is not, but the problem on how to achieve action competence remains. One issue with action competence is that it is often seen as a state that a student either has or has not achieved. However, examining the results of **Study III** show that drawing a line in what is and what is not action competence is challenging. Challenges in drawing this line are also seen in the need for extensive explanations on what action competence is, written by Jensen and Schnack (1997).

Rather than seeing action competence at a state that can be reached, it would be more beneficial to consider it as an ongoing process - a skill that can be developed. Therefore, especially for educational purposes it is beneficial to consider how this development happens. A suggestion for such a model is presented in Figure 4 and explained below.

Figure 4. *A model on how to develop students' action competence* (applied from Juntunen & Aksela, 2014; Jensen & Schnack, 1997)

1. **Find a problem**: Students find an environmental problem that affects their immediate community (e.g. air quality) or is a global environmental problem (e.g. climate change). In **Study III**, most students have already done this, but this may not be the case in a typical classroom.
2. **Develop action**: Students then brainstorm different types of actions that could be taken in order to contribute to solving this environmental problem.
3. **Take Action**: Students choose one or more action that they wish to take to mitigate the environmental problem. As **Study III** shows, students will take a variety of different types of actions, with varying impact on the environment.
4. **Analyze action**: Critical thinking is a central element of developing action competence (Mogensen, 1997). Therefore, students need to critically analyze the actions they are taking. For instance, students could analyze the environmental,

societal and economic impact of their actions. To do such an analysis, the students need to study issues related to a problem, such as looking at a product's environmental impact and life-cycle. The depth of the analysis should be determined by the learning goals and the students' competence. The goal of the analysis should be to pinpoint shortcomings or discrepancies ***in the action***. In an ESD context this could mean realizing that the paper bags that a student has started using may, in fact, be more harmful to the environment than plastic bags. Especially the analysis and further development of actions is what differentiates actions from mere behavior (see Jensen & Schnack, 1997).

5. **Find a (new) problem**: If students don't find any significant areas of improvement in their previous actions, they should be encouraged to keep doing what they are doing and find a new problem that they also start to solve.
6. **Develop action (further)**: If students have found that their action doesn't have a big impact in helping to solve the environmental issue in hand, they should develop their action further, or come up with new actions to solve the problem and then again, test out these actions.

If this process is to be taught in a class-room setting, the studies presented in this thesis suggest that students should receive social support and feedback from peers and the teacher to encourage them in the pursuit. Getting other people involved in the endeavors will also help the student stay focused in developing their actions.

7.3. Students' Expectations of Non-Formal Education

The findings from the third research question, *"What type of expectations do students have for non-formal education with a context of sustainable development?"* coinside with the findings presented in the previous sections as the findings clearly show that in addition to their academic expectations, students also expect meaningful social interaction and the possibility to participate in ethical discussions.

The key expectations from a non-formal education program are similar to the expectations gifted students have about formal education, namely, an advanced academic content (Colangelo et al., 2004) that reflects their interests (Subotnik et al., 2011). A deeper analysis also shows that students expect to be given possibilities to do their own research projects, either through literature reviews or field experiments, as well as learn about the nature of science. The underlying goal, therefore, seems to be to gain a holistic view of science, especially crucial in a sustainable development context.

This implies that students want non-formal education to focus on vocational relevance, not only through gaining more knowledge, but also gaining understanding in how research is done and how the research community operates. To achieve this goal, interactions with the science community are important. In relation to a formal school setting, the findings imply that students should be given more opportunities to plan and execute their own

research projects. Furthermore, setting up a "science community" in the classroom, where students review and critique each other's work, could be beneficial, though should not be used to replace encounters with the real science community (e.g. through company visits). The expectations of the students also show that education should provide students with the understanding on how political and financial aspects play a part in what type of research is conducted (see Hodson, 2008 for more discussion on NOS).

Furthermore, this study emphasized the importance of social relationships. Previous research has indicated that social aspects are an important part of education, as they can motivate students and affect their view on education (e.g. Bliuc et al., 2011; Tirri & Kuusisto, 2013). However, as seen in this study, students also want to be surrounded by a social network so that they can learn from their peers and collaborate with them. Students see international collaboration as especially beneficial when dealing with sustainability issues.

The findings show that students are keen to share their own experiences on sustainable development, as well as to hear how other countries deal with sustainability issues. Alhough the significance of exchanging ideas with international peers is not studied in this thesis, a reasonable hypothesis is that such encounters increase self-awareness on the topic, further increasing action competence. Furthermore, discussion on national policies towards sustainability can increase understanding on societal relevance. Therefore, based on the results, when dealing with sustainable development, international collaboration between schools should be developed in formal education, as well.

The results of **Study III** also indicate that gifted students are aware that sustainability issues are multifaceted, as is seen in their high expectations for ethical discussions. However, the expectations imply that at least some students want to know what is right and what is wrong. Dealing with issues related to sustainable development provides the platform to discuss how there may not be a right or wrong answer to certain questions, but rather, the answer depends on the interests of the person who is asked. Mixed interests and the challenges of evaluating certain scientific processes or products as good or bad are well presented in a research conducted by Burmeister and Eilks (2012), which analyzes the environmental, economic and practical benefits of different plastics.

7.4. Meeting Students' Needs and Expectations through Non-Formal Education

As was presented in the previous sections, students have a wide range of expectations regarding heir education, ranging from academic, societal, social and ethical aspects. This section discusses how non-formal education can work as a means to meet these expectations.

Previous studies have already shown that non-formal education has many positive effects, such as increasing students' interest in science (E. Pedretti, 2002), as the students build meaningful social relationships (Rahm, 2004) and work with themes that are of interest to them. The studies presented in this section contribute to the discussion on the importance of non-formal education by: (i) showing that non-formal education can address

all three dimensions of relevance (**Study V**), (ii) discussing how specialists working at the camp are able to meet different dimensions of relevant education (**Study IV**), and (iii) addressing how non-formal education can meet students' academic, social and ethical/emotional expectations (**Study VI**).

First, **Study V** shows that creating a camp curriculum around the students' needs and expectations provides all three dimensions of relevance in a fairly balanced way. As is seen through the other studies presented, many of the students attending the camp have personal interest towards science, and more specifically sustainable development. They have previously worked on personal projects, and have taken actions to mitigate environmental problems. Providing individual relevance in non-formal education, will resonate with these previous projects and experiences. **Study V** also discusses how the camp curriculum provides societal relevance. Here a context of sustainable development is apparent, as it helps create the link between science and society. Societal relevance is something that is commonly overlooked in science education (Eilks & Hofstein, 2014), but a clear focus on sustainable development could help overcome this. **Study V** shows how the curriculum uses a network of scientists and facilities to provide vocational relevance. Providing students with mentors and role-models may help them decide a career path, and so, this opportunity should be provided in non-formal, as well as formal education if more scientists are to be recruited.

Study IV shows how non-formal education provides a great platform to deal with timely issues through projects that focus on knowledge increase, creative thinking, learning about academic and professional opportunities, peer interaction and discourse on ethical issues. The study also shows that when sustainable development is set as a goal for an educational program, specialists will find ways to incorporate a multidisciplinary approach to the scientific issues that are dealt with. The specialists noticed that when they did so, students had courage to discuss ethical issues related to the scientific topics. Some specialists noted that these discussions happened spontaneously among the students and that the students also had courage to ask ethical questions from experts from universities and representatives of companies. Encountering such discussion could partly be because gifted students tend to have high moral sensitivity (Gowda, Fox, & Magelky, 1997). It is also reasonable to assume that the camp environment, with its diverse social activities and creative projects, gave students more courage to ask questions on controversial issues. The reason to assume so is that earlier research has shown that culture and environemt affect self-expression (Kim & Sherman, 2007). Providing an encouraging environment for self-expression will also make sharing ethical views possible.

Though several of the specialists working at the camp were able to actualize ethical goals, the results do indicate that they were harder to incorporate than academic and social goals. Based on the results it seems that some of the specialists did not see the importance of implementing the ethical issues, or they found it hard to incorporate them into the project. This can also be the case in formal education: Issues related to sustainable development may be seen as important, but not important enough to change the content of the curriculum or the pedagogical methods used. Dealing with such complex issues can be challenging for a teacher, as they need to change their role from information giver to facilitator. Furthermore, they may not want to give up the integrity of their subject

(Gayford, 2002). Therefore, helping pre-service and in-service teachers understand that they are not only teaching the science knowledge of a subject, but rather, are involved in citizenship education, may help change their perception. Furthermore, teacher training should focus on how to change roles from an information provider to that of a facilitator. Furthermore, more research is needed on why teachers select the pedagogical methods that they do, even though they may not meet the learning goals they have in mind.

Study VI gives further insight on how the students' academic, social and ethical needs can be met through non-formal education by discussing the meaningful interactions that take place during the non-formal program. As was already seen in the expectations, students want to work in an international atmosphere, where they can share ideas with people from different parts of the world. The Millennium Youth Camp provided this opportunity by having an international evening, where students learned about each other's countries and cultures. Moreover, the working groups consisted of students from many different nations, making the groups highly international. Meeting students from different parts of the world also increased the individual relevance of the projects, as students realized the different impacts that environmental issues such as climate change, may have on their friends living in different parts of the world.

The expectations also showed that students want to discuss science related topics with experts and peers. This opportunity was provided by having specialists guide the group projects and by making them easily available throughout the week long camp. As the students became familiar with the experts during the camp, they felt more comfortable asking hard questions and talking about ethical issues.

The longitudinal study (in **Study VI**) showed that non-formal educational programs can become meaningful events in a students' life, inspiring them and providing them with more self-confidence. However, as some other researchers argue that non-formal educational programs are not necessary for gifted students to achieve well (Hany & Grosch, 2007), further research on the topic should be made. Regarding educational reform, it would be especially valuable to know the type of elements of which a meaningful encounter consist, and how these elements can be enforced in education to make it more relevant for the students.

7.5. Implications

This thesis sought to examine ways to make science education more relevant. The findings show that students want education for sustainable development to consist of academic, societal, social and ethical aspects. In other words, students want education to be holistic.

The students' questions imply that if students were given more freedom to focus on the sustainability issues they are interested in, they would examine the issue from a scientific, societal and ethical perspective. Students' actions are also multifaceted, showing that they have a level of action competence. In order to address students' questions and help them develop their action competence, new pedagogical approaches are needed. Some suggestions are presented in this thesis, but still need to be tested in practice. The vast

array of students' questions and actions show that there is much that can be incorporated into student-centered education. However, pre-service and in-service teacher training in student-centered learning approaches are needed.

The thesis also gives implications on how non-formal education could address some of the educational needs. For instance, non-formal education could provide the platform for students to work on their own project under the support of specialists. Furthermore, non-formal education can provide meaningful encounters in an international community with both peers and experts. The thesis also implies that some social programs are more effective than others in helping students meet their social and ethical needs. In essence, the findings give suggestions on what aspects should be incorporated to non-formal education in order to provide a holistic learning environment where students' academic, societal, social and ethical needs are met.

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